Second Semester Examination
2017/2018 Academic Session

May/June 2018

EAS356 – Reinforced Concrete Structural Design II
(Rekabentuk Struktur Konkrit Bertetulang II)

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions : This paper consists of **FIVE (5)** questions. Answer **FOUR (4)** questions.
*[**Arahan** : Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT (4)** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a). The manufacturer's catalogue for 250 mm × 250 mm square piles showed that the maximum structural load for design purpose is 890 kN. An engineer in your office proposed to use this value in order to reduce the number of piles for a development project. The piles shall be driven to 30 meter depth. As a professional engineer, you know that it would be very risky to use maximum strength of the pile. Provide your technical explanation from structural engineering point of view.

Katalog pengeluar untuk cerucuk segiempat 250 mm × 250 mm menunjukkan beban struktur maksimum untuk kegunaan rekabentuk adalah 890 kN. Seorang jurutera di pejabat anda mencadangkan agar nilai ini digunakan untuk mengurangkan bilangan cerucuk bagi satu projek pembinaan. Cerucuk ini akan ditanam pada kedalaman 30 meter. Sebagai seorang jurutera bertauliah, anda mengetahui bahawa ianya berisiko tinggi untuk menggunakan kekuatan maksimum cerucuk. Sediakan keterangan teknikal anda dari sudut pandangan kejuruteraan struktur.

[5 marks/*markah*]

(b). The use of permanent steel casing will increase the construction cost. This situation is unavoidable for very weak soil strata above the layer of bedrock that may cause collapse to the drilled hole. However, an experienced structural engineer still can reduce the impact to the construction cost by selecting the appropriate design approach. Using this case as a reference, design the allowable pile working capacity and cross sectional detailing of a 200 mm diameter micro pile reinforced with FOUR (4) 16 mm diameter bar. Assume grout strength = 25 N/mm^2, f_{yk} = 500 N/mm^2, E(grout) = 14 GPa, E(steel) = 200 GPa and Factor of Safety = 2.0.

Penggunaan selongsong keluli kekal akan meningkatkan kos pembinaan cerucuk mikro. Situasi ini tidak dapat dielakkan apabila terdapat strata tanah yang sangat lemah diatas lapisan batuan dasar yang boleh menyebabkan keruntuhan kepada lubang penggerudian. Namun demikian, seorang jurutera struktur yang berpengalaman masih boleh mengurangkan impak kepada kos pembinaan dengan memilih pendekatan rekabentuk yang sesuai. Dengan berpandukan kes ini, sediakan rekabentuk keupayaan kerja cerucuk dibenarkan dan perincian keratan rentas cerucuk mikro bergarispusat 200 mm yang diperkuat menggunakan EMPAT (4) tetulang bergarispusat 16 mm. Anggap kekuatan turap = 25 N/mm^2, f_{yk} = 500 N/mm^2, E(turap) = 14 GPa, E(keluli) = 200 GPa dan Faktor Keselamatan = 2.0.

[8 marks/*markah*]

(c). During a technical briefing, a newly appointed structural engineer presented the proposed cross sectional detail of a 900 mm diameter bored pile as shown in **Figure 1**. The pile will be used at a construction site where the soil is chloride-free and will be subjected to long-term water contact. The terms of reference for the project stated that the structural design of all piles must be in accordance to BS EN 1992-1-1, 50 years design life and only subjected to axial load. If the allowable pile working capacity is 4000 kN, evaluate the structural integrity and the detailing of the proposed bored pile.

Semasa taklimat teknikal, seorang jurutera yang baru dilantik telah membentangkan cadangan perincian keratan rentas satu cerucuk tergerek bergarispusat 900 mm seperti di ***Rajah 1****. Cerucuk tersebut akan digunakan di tapak pembinaan yang tanahnya adalah bebas klorida dan terdedah kepada sentuhan air yang berpanjangan. Terma rujukan untuk projek tersebut menyatakan semua rekabentuk struktur cerucuk mesti mengikut BS EN 1992-1-1, 50 tahun hayat rekabentuk dan hanya akan menanggung beban paksi. Sekiranya keupayaan kerja cerucuk dibenarkan adalah 4000 kN, sediakan penilaian terhadap integriti struktur dan perincian yang telah dicadangkan.*

[12 marks/*markah*]

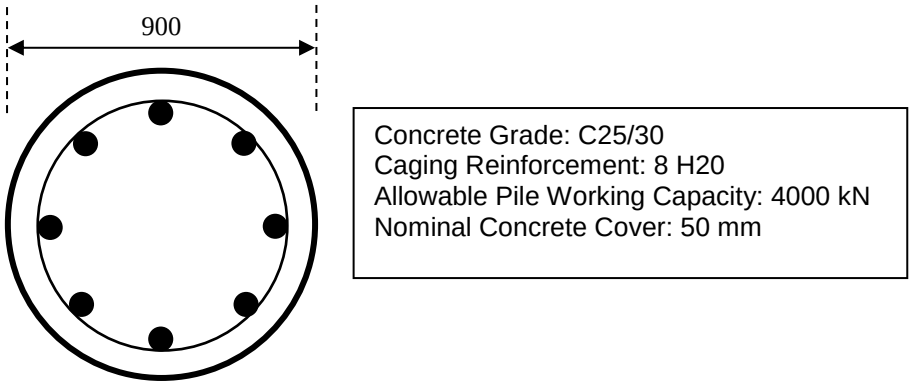

Figure 1 (all dimensions in mm) / ***Rajah 1(semua ukuran dalam mm)***

2. (a). The proposed plan view of a pile cap with six pile group for a high rise building project is shown in **Figure 2**. The pile cap is required to support unfactored column load with G_k = 3800 kN and Q_k = 800 kN. If the overall depth of the pile cap is taken as 1000 mm, provide the design and cross sectional detailing considering that the f_{ck} = 35 N/mm^2, f_{yk} = 500 N/mm^2 and pile embedded length = 75 mm. Use reinforcement H25 and H16 mm for resisting maximum and minimum moment, respectively. Ignore the check for maximum shear resistance at the column face, the reinforcement spacing and the anchorage length (only sketch the anchorage length for detailing purposes). The vertical shear check is only required for maximum moment at critical section.

Cadangan pandangan pelan tetopi cerucuk dengan sekumpulan enam cerucuk untuk satu projek bangunan tinggi adalah seperti di ***Rajah 2****. Tetopi cerucuk tersebut diperlukan untuk menanggung beban tiang tidak terfaktor G_k = 3800 kN, Q_k = 800 kN. Jika kedalaman keseluruhan tetopi cerucuk adalah 1000 mm, sediakan rekabentuk dan perincian keratan rentas dengan mempertimbangkan f_{ck} = 35 N/mm^2, f_{yk} = 500 N/mm^2 dan panjang tertanam cerucuk = 75 mm. Gunakan tetulang H25 dan H16 masing-masing untuk merintang momen maksimum dan minimum. Abaikan semakan rintangan ricih maksimum pada permukaan tiang, selaan tetulang dan panjang tambatan (hanya lakarkan panjang tambatan bagi tujuan perincian). Semakan ricih pugak hanya diperlukan untuk momen maksimum di keratan kritikal.*

[20 marks/*markah*]

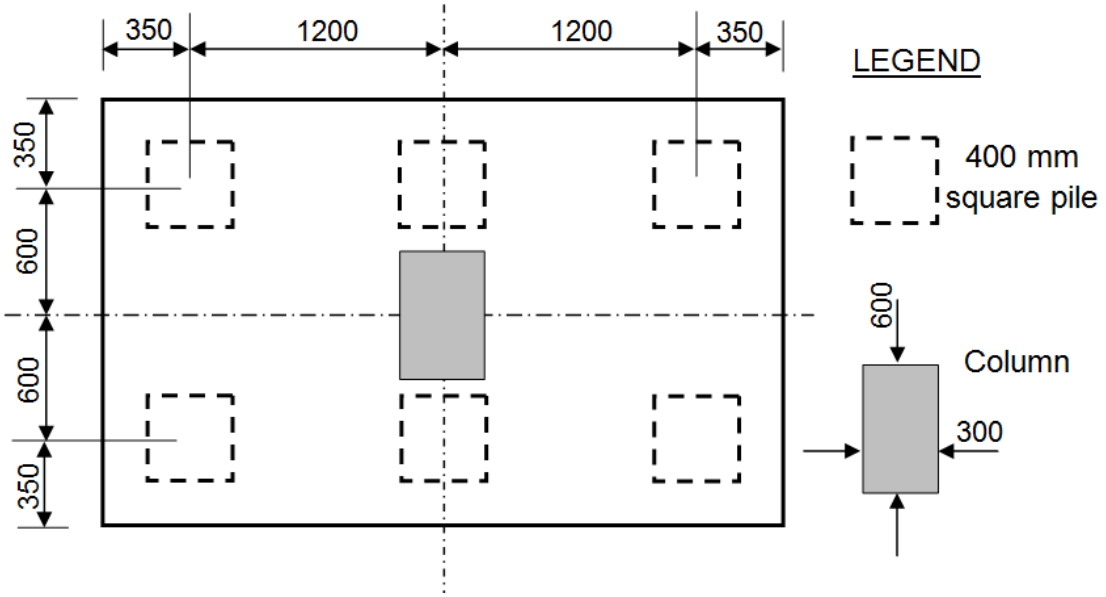

Figure 2 (all dimensions in mm)/*Rajah 2 (semua ukuran dalam mm)*

(b). The client for the high rise building project in (a) accepted the proposed piling size and pile cap details. However, the client appreciates if your design office could perform cost saving calculation to the pile cap. One of your colleagues suggested that the overall depth of the pile cap should be increased. Evaluate his suggestion (no structural calculation is required), assuming that the plan area and orientation of the pile cap remain unchanged. Propose and justify another approach that has the potential of saving the construction cost.

Klien kepada projek bangunan tinggi di (a) tersebut bersetuju dengan cadangan saiz cerucuk dan perincian tetopi cerucuk. Namun demikian, klien tersebut menghargai sekiranya pejabat rekabentuk anda boleh membuat pengiraan penjimatan kos terhadap tetopi cerucuk. Salah seorang rakan kerja anda mencadangkan agar kedalaman keseluruhan tetopi cerucuk tersebut ditambah. Buat penilaian terhadap cadangan beliau (tiada pengiraan struktur diperlukan) dengan menganggap luas pelan dan orientasi tetopi cerucuk tidak berubah. Cadangkan beserta justifikasi satu lagi pendekatan yang berpotensi untuk menjimatkan kos pembinaan.

[5 marks/*markah*]

3. (a). The piling work for the construction of a four star hotel has completed. The contractor engaged a licensed land surveyor firm to prepare the As-Built piling drawing and to be submitted to the design office. Upon receiving the drawing, a structural engineer superimposed the given information with the pile cap drawing. The actual distance, measured from the center of the piles to the respective axes is shown in **Figure 3**. The allowable pile working capacity is 800 kN. If the column load and selfweight of the pile cap are calculated to be 4500 kN, evaluate the pile capacity individually and as a group.

Kerja cerucuk untuk pembinaan satu hotel bertaraf empat bintang telah disiapkan. Pihak kontraktor telah melantik firma juruukur tanah bertauliah untuk menyediakan lukisan cerucuk terbina dan menyerahkannya kepada pejabat rekabentuk. Setelah menerima lukisan tersebut, seorang jurutera struktur menindan data yang diberikan dengan lukisan tetopi cerucuk. Jarak sebenar yang diukur dari titik tengah cerucuk ke paksi yang berkaitan ditunjukkan di ***Rajah 3****. Keupayaan kerja cerucuk dibenarkan adalah 800 kN. Sekiranya beban tiang serta swa-berat tetopi cerucuk dikira sebagai 4500 kN, nilaikan keupayaan cerucuk secara individu dan kumpulan.*

[25 marks/*markah*]

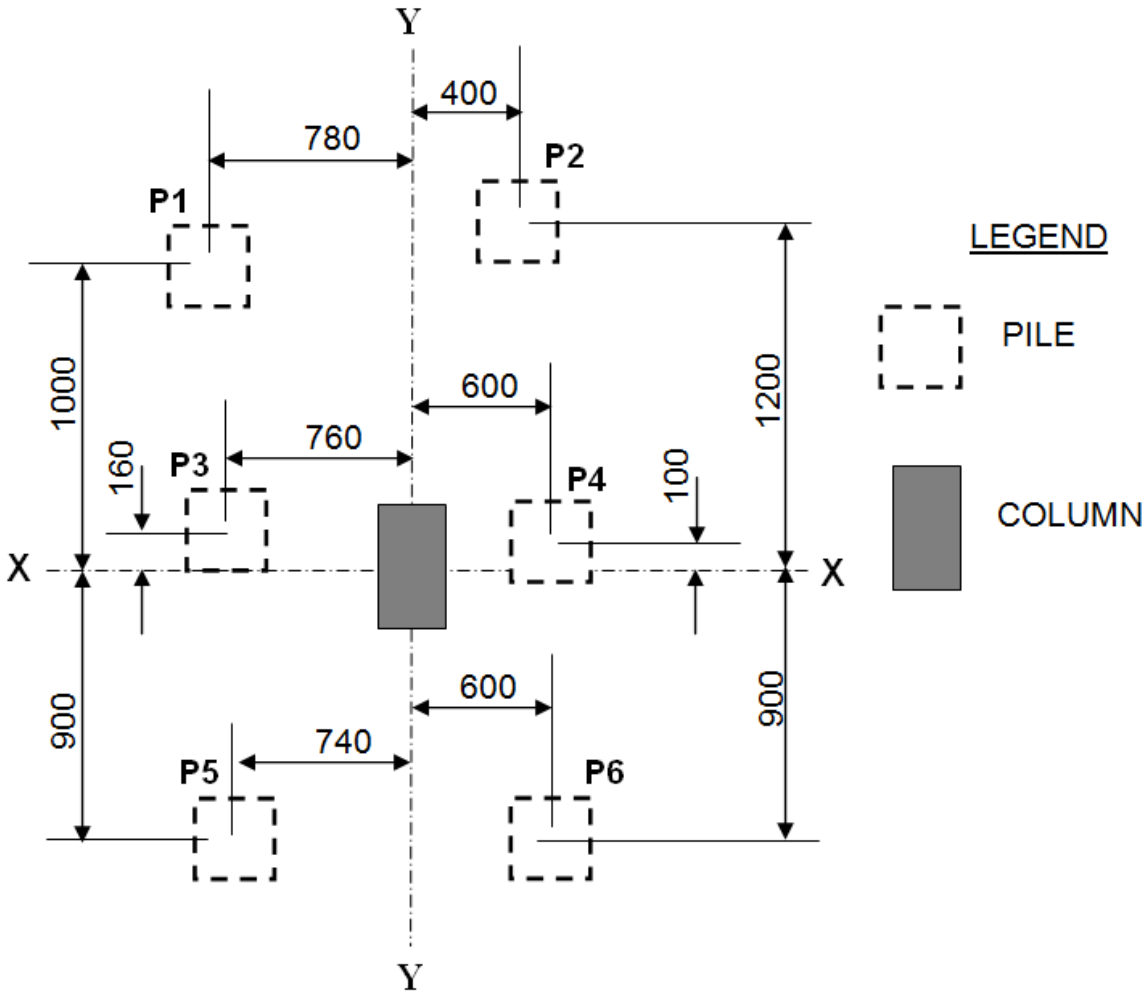

Figure 3 (all dimensions in mm) /*Rajah 3 (semua ukuran dalam mm)*

4. A flat slab construction is required for a housing project. The part plan of the internal layout for the slab is shown in **Figure 4**. The slab should be 250 mm thick together with 2500× 2500×150 mm drop panels. If the ultimate design load is 10 kN/m^2, design the flat slab and check the punching shear requirements within the drop panel only. Provide typical sectional details along the column strip and middle strip. Use H12 reinforcement (f_{yk} = 500 N/mm^2) and grade 30 concrete (f_{ck}= 30 N/mm^2). The diameter of the column head (h_c) and the concrete cover is taken as 1200 mm and 25 mm, respectively. Assume imposed load, Q_k as 5 kN/m^2.

Pembinaan lantai rata adalah diperlukan untuk satu projek perumahan. Sebahagian pelan susun atur dalaman untuk lantai rata ditunjukkan di ***Rajah 4****. Lantai tersebut mestilah 250 mm tebal dan mempunyai panel jatuhan 2500×2500×150 mm. Jika beban rekabentuk muktamad adalah 10 kN/m^2, rekabentuk lantai rata tersebut dan semak keperluan ricih tebukan dilingkungan panel jatuhan sahaja. Sediakan perincian tipikal disepanjang jalur tiang dan jalur tengah. Gunakan tetulang H12 (f_{yk} = 500 N/mm^2) dan konkrit gred 30 (f_{ck}= 30 N/mm^2). Garis pusat kepala tiang (h_c) dan penutup konkrit masing-masing diambil sebagai 1200 mm dan 25 mm. Anggap beban kenaan, Q_k sebagai 5 kN/m^2 .*

[25 marks/*markah*]

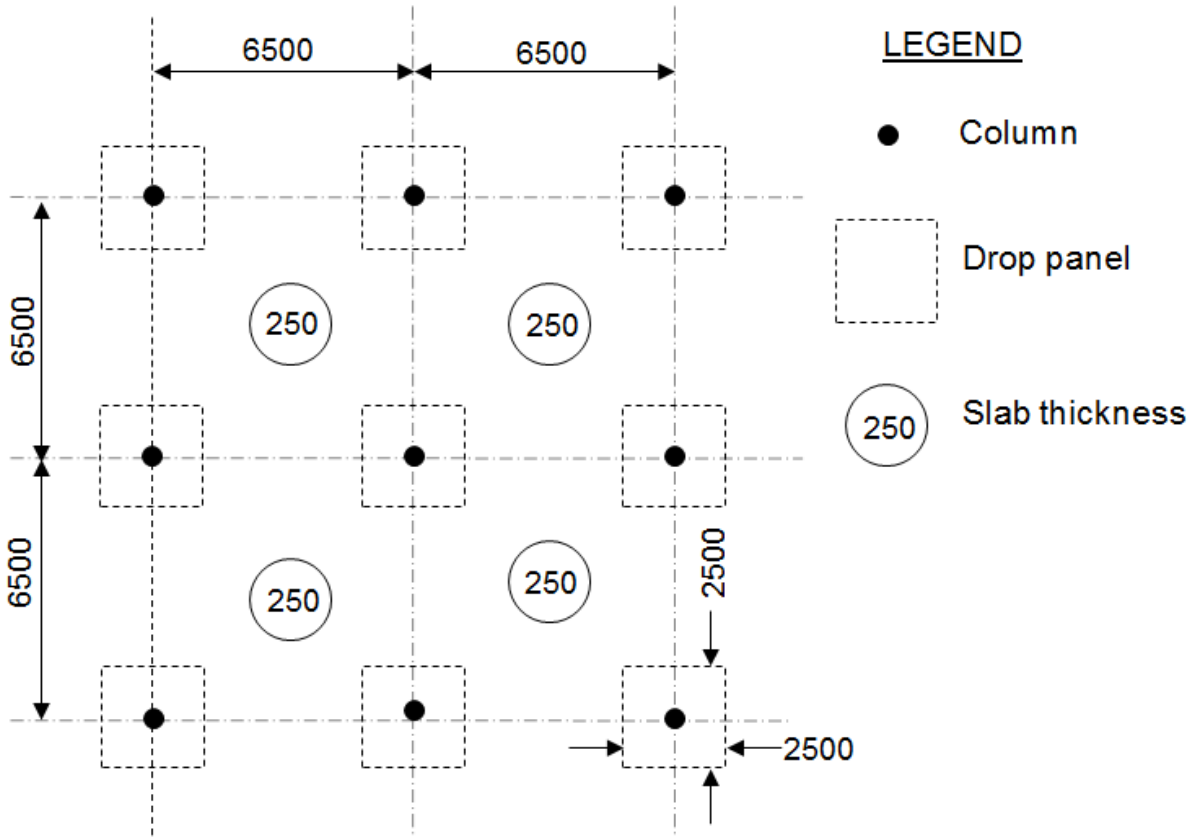

Figure 4 (all dimensions in mm)/*Rajah 4 (semua ukuran dalam mm)*

5. Design a cantilever wall as shown in **Figure 5** to retain earth with horizontal backfill and surcharge load of 10 kN/m^2. The top of the wall is 4.5 m above the ground level, and the foundation depth may be taken as 0.4 m below ground level, with the safe bearing capacity of 170 kN/m^2. Assume the backfill has a unit weight of 19 kN/m^3 and an angle of shearing resistance of 35˚. The coefficient of friction between soil and concrete is 0.45. Use concrete grade 30 (f_{ck} = 30 N/mm^2), H12 reinforcement (f_{yk} = 500 kN/m^2) and nominal concrete cover as 45 mm.

Rekabentuk sebuah dinding julur seperti yang ditunjukkan pada ***Rajah 5*** *untuk menahan beban kambus balik melintang dan beban tambahan 10 kN/m^2. Bahagian dinding atas adalah 4.5 m diatas aras bumi dan kedalaman asas adalah 0.4 m dibawah aras bumi dengan keupayaan galas selamat 170 kN/m^2. Anggap beban kambus balik mempunyai berat unit 19 kN/m^3 dan sudut rintangan ricih* 35˚. *Pekali geseran diantara tanah dan konkrit adalah 0.45. Gunakan konkrit gred 30 (f_{ck} = 30 N/mm^2), tetulang H12 (f_{yk} = 500 kN/m^2) dan penutup konkrit nominal adalah 45 mm.*

[25 marks/*markah*]

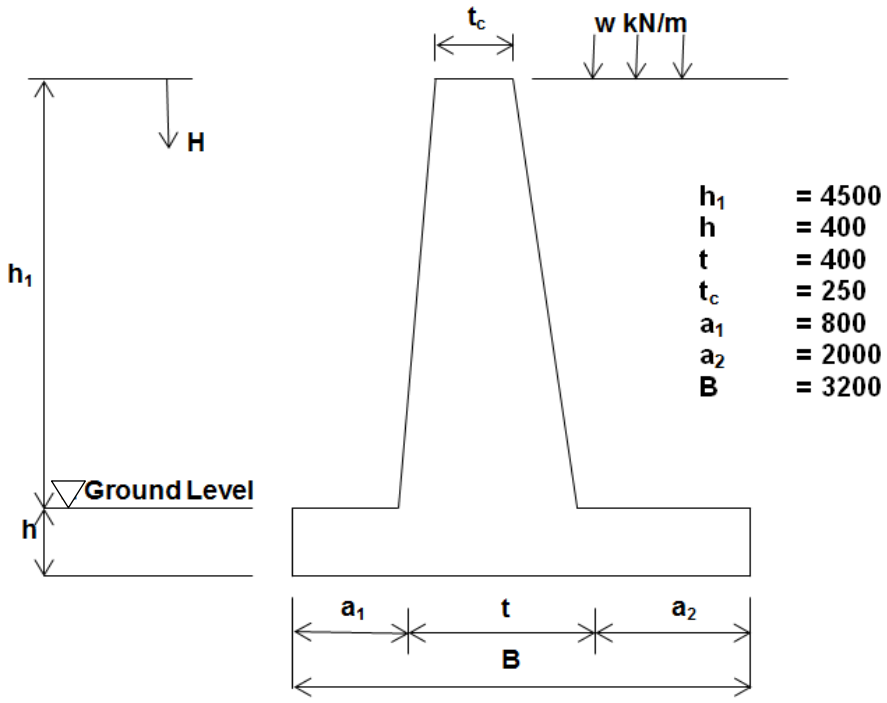

Figure 5 (all dimensions in mm)/*Rajah 5 (semua ukuran dalam mm)*

APPENDIX/*LAMPIRAN*

1. Pile capacity check:

$$P_n = \frac{P}{N} \pm \frac{M_{xx}\, y_n}{I_{xx}} \pm \frac{M_{yy}\, x_n}{I_{yy}}$$

2. Design shear resistance:

$$V_{Rd,c} = 0.12k(100\rho_1 f_{ck})^{\frac{1}{3}}\, bd$$

3. Minimum area of reinforcement:

$$A_{s,min} 0.26 \left(\frac{f_{ctm}}{f_{yk}}\right)\, bd$$

4. Ultimate bending moment in one-way spanning slabs

Ultimate bending moment and shear force in one way spanning slabs		
	Middle interior spans	Interior supports
Moment	0.063 *Fl*	0.063 *Fl*
F = is the total design load (1.35 *Gk* + 1.5 *Qk*) in kN; *l* = effective span		

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5. Distribution of design moments in panel of flat slabs

Design moment	**Apportionment between column and middle strip expressed as percentage of the total negative or positive design moment**	
	Column strip %	**Middle strip %**
Negative	75	25
Positive	55	45
NOTE: For the case where the width of the column strip is taken as equal to that of the drop, and the middle strip is thereby increased in width, the design moments to be resisted by the middle strip should be increased in proportion to its increased width. The design moments to be resisted by the column strip may be decreased by an amount such that the total positive and the total negative design moments resisted by the column strip and middle strip together are unchanged.		

Table 3: Steel stress (under quasi-permanent loading)

f_s	$= \frac{f_{yk}\,(G_k + 0.3Q_k)}{1.15(1.35G_k + 1.5Q_k)}\ x\ \frac{A_{s,req}}{A_{s,pro}}$

Bar Areas and Perimeters

Sectional areas of groups of bars (mm^2)

Bar Size (mm)	Number of bars							
	1	2	3	4	5	6	7	8
6	28.3	56.6	84.9	113	142	170	198	226
8	50.3	101	151	201	252	302	352	402
10	78.5	157	236	314	393	471	550	628
12	113	226	339	452	566	679	792	905
16	201	402	603	804	1010	1210	1410	1610
20	314	628	943	1260	1570	1890	2200	2510
25	491	982	1470	1960	2450	2950	3440	3930
32	804	1610	2410	3220	4020	4830	5630	6430

Sectional areas per metre width for various bar spacings (mm^2)

Bar Size (mm)	Spacing of bars							
	75	100	125	150	175	200	250	300
6	377	283	226	189	162	142	113	94.3
8	671	503	402	335	287	252	201	168
10	1050	785	628	523	449	393	314	262
12	1510	1130	905	754	646	566	452	377
16	2680	2010	1610	1340	1150	1010	804	670
20	4190	3140	2510	2090	1800	1570	1260	1050
25	6550	4910	3930	3270	2810	2450	1960	1640
32	10700	8040	6430	5360	4600	4020	3220	2680

A_{sv}/s_v for varying stirrup diameter and spacing

Stirrup diameter (mm)	Number of bars										
	85	90	100	125	150	175	200	225	250	275	300
8	1.183	1.118	1.006	0.805	0.671	0.575	0.503	0.447	0.402	0.366	0.335
10	1.847	1.744	1.57	1.256	1.047	0.897	0.785	0.698	0.628	0.571	0.523
12	2.659	2.511	2.26	1.808	1.507	1.291	1.13	1.004	0.904	0.822	0.753
16	4.729	4.467	4.02	3.216	2.68	2.297	2.01	1.787	1.608	1.462	1.34

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